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DISCUSSION ON PROBLEMS IN BUCKLING ANALYSIS OF A CONTINUA

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Abstract. In linear buckling analysis the eigenvalue problem, that constitutes the background for estimating critical buckling load, is

$$([S_0] + \lambda[S_\sigma])) \{\Delta\} = \{0\} \tag{1}$$

where $[S_0]$ is the initial global stiffness matrix and $[S_\sigma]$ is the stress stiffness matrix that is part of the tangential stiffness matrix, both obtained based on linear elasticity. The matrix $[S_\sigma]$ is obtained by a reference load vector $\{\bar{A}\}$ and a factor on $\{\bar{A}\}$ implies the same factor on $[S_\sigma]$. The estimated critical buckling load vector is $\{A\}_C = \lambda_1\{\bar{A}\}$ where λ_1 is the lowest eigenvalue for the eigenvalue problem (1). From the assumption of linearity between $\{\bar{A}\}$ and $[S_\sigma]$ follows directly, that the critical buckling load vector $\{A\}_C$ is independent of the size(norm) of $\{\bar{A}\}$. This implies uncertainty in linear buckling analysis, and this is illustrated by applying geometrical non-linear displacement analysis, that shows that buckling load also depends on the norm of $\{\bar{A}\}$. The relations between the individual stress components in a finite element are unchanged for linear buckling analysis. However, with geometrical non-linear displacement analysis this is not the case, even assuming material linear elasticity. This also give doubts to the estimated buckling load, obtained by linear buckling analysis. The geometrical non-linear buckling analysis is based on the full tangential stiffness matrix $[\bar{S}_t]$ that is separated in a gamma stiffness matrix $[\bar{S}_\gamma]$ and a stress stiffness matrix $[\bar{S}_\sigma]$. These matrices depend on a reference load $\{\bar{A}\}$ and therefore the stiffness matrices contain a bar notation and must be determined by iteration. The eigenvalue problem for non-linear buckling analysis is interpreted as an extrapolation along the tangential stiffness matrix

$$([\bar{S}_\gamma] + \lambda[\bar{S}_\sigma]) \{\Delta\} = \{0\} \tag{2}$$

Applying this approach for estimating non-linear buckling analysis, comparison to (1) is used to show errors from linear buckling analysis, i.e., for initial uniform and unchanged design the buckling load as a function of the size(norm) of reference load $\{\bar{A}\}$ is shown not to be constant. A cantilever beam-column and a frame of two beam-columns are used as examples.